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THE NATIONAL IGNITION FACILITY AND ITS LASER TECHNOLGY

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NIF PROJECT MISSION

The National Ignition Facility (NIF) will house the world's most powerful laser. The high-energy-density conditions created by NIF are expected to achieve both ignition and energy gain for the first time in a laboratory. This will have far-reaching implications for the future of national security, fusion energy, industrial competitiveness, and a host of scientific and technological fields.

The NIF, currently in preliminary design, will have 192 laser beams to focus a total of 1.8 MJ, 500 TW onto capsule of deuterium and tritium a few millimeters in size, forcing the two heavy isotopes of hydrogen to combine through compression and heating (to 50 million degrees), producing ignition and a self-sustaining fusion reaction.[1] Two kinds of targets are under study[2] indirect and direct drive targets, both of which can be used in the NIF. The fuel capsule of indirect drive targets are inside a small, thin-walled cylindrical container made from high-atomic-number materials such as gold or lead. The container, called a hohlraum, converts the laser beams to x-rays, which in turn compress the fuel capsule. The other type are direct-drive targets, in which a spherical capsule containing the fusion fuel is struck directly by the laser beams.

With construction costs of $1.1 billion, the football stadium-sized facility will have tremendous impact on the nation's Inertial Confinement Fusion research program when it becomes operational in the year 2003. Because it can produce, on a tiny scale, temperatures and pressures that occur in nuclear weapons, NIF will help scientists understand changes that can occur as a weapon ages and verify advanced computer codes necessary to maintain confidence in weapon performance and reliability. By providing this capability, NIF contributes to U.S. programs for stewardship and management of nuclear weapons, arms-control treaty negotiations, and nuclear test verification. NIF can also provide answers to important energy questions. Once researchers prove that inertial confinement fusion can produce more energy than is used to create ignition, the foundation for future commercial fusion power production will have been laid.

NIF LASER TECHNOLOGY

In order to reach the cost and performance requirements of NIF, major advances in design and laser technology are needed and are currently under development at Lawrence Livermore, Los Alamos, and Sandia National Laboratories.[3, 4] The design uses a four-pass laser architecture to achieve higher energy per unit cost compared to single-pass systems. The low-energy input pulse (about 2 J) is amplified in four passes through two amplifier modules, which are separated by unity-magnification spatial filter to minimize the growth on nonlinear self-focusing. The laser gain medium is neodymium-doped, flashlamp-pumped, phosphate-glass slabs. The flashlamps are driven by the power conditioning system, which is capable of delivering over 300 MJ of electrical energy in the NIF design. This architecture requires an optical switch that deflects the beam out of the laser cavity after the fourth pass. For this purpose, a large aperture plasma-electrode Pockels cell is located inside the laser cavity to cause polarization rotation of the beam after four passes; this causes the beam to reflect off of the polarizer and out of the cavity. Additional gain of the laser is provided by the booster amplifier both before the beam is injected into the laser cavity and after it has exited. The booster amplifier reduces the optical fluence on the polarizer. The laser energy extracted from each beamline will be almost 20 kJ. At the 10 m diameter vacuum target chamber, the laser beam is frequency converted from 1053 to 351 nm wavelength using a pair of KDP crystals (one of which is deuterated). The beam is focused by a lens and passed through an efficient kinoform phase plate (to control beam uniformity on target) and through a debris shield to protect the output optics against target debris.

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